

INSTRUCTION MANUAL



**UTILITY MASTER PLUS
MULTIFUNCTION METER
MODEL UM-7900**

F.W. BELL

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Model UM-7900 Utility Master Plus Operating Instruction Manual

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Model LM-7000
Lightly Modified
Operating Instruction Manual

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R.W. BELL

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I — SAFETY HINTS

1. Observe all maximum circuit voltage cautions.
2. The aperture is insulated except at the core closure. Withstand capability from core to voltage leads is safe for voltages specified. Do not permit core to come in contact with uninsulated conductors.
3. Inspect voltage input leads frequently for cracks, burns, etc. Do not use if leads become damaged.
4. Prolonged operation above 250 A•kHz can cause permanent damage due to heating effects. Do not use probe under conditions where the current frequency product is higher than 250 A•kHz.
5. Do not expose the RS232 interface lines to voltages higher than those specified, or damage will result.

II — SIMPLIFIED OPERATING INSTRUCTIONS

1. Slide battery compartment door back, install a 9-volt alkaline battery, and slide door back into position.
2. Slide ON/OFF switch to the ON position. Wait for BELL and a flashing ZERO to appear.
3. To zero the meter, make sure no current is flowing through the aperture, and press both pushbuttons simultaneously. Wait for the VOLTS AC function to appear.
4. To select the desired reading, press and release the right-hand pushbutton.
5. To select or release the PEAK HOLD function, press and release the left-hand pushbutton.
6. To illuminate the display, press both pushbuttons, and release in less than two seconds.
7. To rezero the meter, press and hold both pushbuttons for longer than two seconds.
8. Refer to Section VIII for more detailed instructions.

III — SPECIFICATIONS

(T_A = 25°C and frequencies are dc and 45 to 65 & 380 to 420 Hz)

PARAMETER	RANGE	ACCURACY
ac VOLTAGE	90 to 660 Vac	±1.0% of reading, ±2 V
ac CURRENT	1 to 25 A ac 25 to 1,000 A ac	±1.0% of reading, ±1.5 A ±1.5% of reading, ±3.0 A
dc CURRENT	±1 to 25 A dc ±25 to 1,400 A dc	±1.0% of reading, ±1.5 A ±1.5% of reading, ±3.0 A
FREQUENCY	40 to 500 Hz	±0.4% of reading
PHASE ANGLE	0 to ±60°	±6° max.
POWER FACTOR	0.5 to 1.000	≤±0.08 max.
ACTUAL POWER (kW)	1 to 660 kW	<10 kW ±2% of reading, ±1 kW 10 kW to 660 kW ±2% of reading, ±1.0% FS
APPARENT POWER (kVA) (At ±60°±1.75%, Worst Case)	1 to 660 kVA	<10 kVA ±2% of reading, ±0.5 kVA 10 kVA to 100 kVA ±2% of reading, ±1 kVA >100 kVA ±2% of reading, ±2 kVA
REACTIVE POWER (kVARS) (at 0°±1.75%, Worst Case)	1 to 570 kVARS	±3% of reading, ±5 kVARS

ADDITIONAL INFLUENCES ON ACCURACY

CONDUCTOR OFF CENTER <2.0% of reading with 0.63 inch (16 mm) or larger diameter cable

ADJACENT CONDUCTOR CURRENT <0.015 A/A

CORE CLOSURE REPEATABILITY <0.5% of reading

DC CURRENT REVERSIBILITY <0.5% of reading

PHYSICAL PARAMETERS

BATTERY LIFE	8 hours continuous
TEMPERATURE RANGE	0°C to +50°C
STORAGE TEMPERATURE	0°C to +60°C
VOLTAGE WITHSTAND	4600 V, 60 Hz between core and probe output for 1 minute (test requirement for 660 working volts)
BATTERY	1 ea, 9 V alkaline battery (NEDA 1640A)
APERTURE SIZE	2.4" x 2.9"
WEIGHT	1 lb., 13 ozs.

RS232 (SERIAL) INTERFACE

BAUD RATE	1200
STOP BITS	1 Bit
PARITY	None
CHARACTER LENGTH	8 Bits
TYPICAL TX OUTPUT VOLTAGE	±3 V to ±7 V
MINIMUM TX OUTPUT LOAD	3 kΩ
RX INPUT VOLTAGE RANGE	±3 V to ±15 V
TYPICAL RX INPUT IMPEDANCE	3.3 kΩ

NOTE: UM-7900 does not require any hand-shaking interface.

*SEE PAGE 8 FOR MORE INFORMATION

Specifications subject to change without notice.

IV — FEATURES

- Battery-operated, fully portable
- Measures and displays nine functions: true rms volts, true rms amps, dc amps, frequency, phase angle, power factor, true, reactive and apparent power
- Displays current direction in DC AMPS mode, and lead/lag relationship between voltage and current in AC mode
- Designed for use with conductors up to 2 $\frac{3}{8}$ " diameter
- Illuminated, custom-formatted liquid crystal display
- PEAK HOLD feature can be used to capture peak events or allow reading to be held after meter is removed from cable
- Pushbutton selection of functions with one-handed operation
- RS232 interface allows remote monitoring and control, or provides a hardcopy of all readings when connected to a serial printer
- Rugged, reliable F.W. Bell quality
- Made in U.S.A.

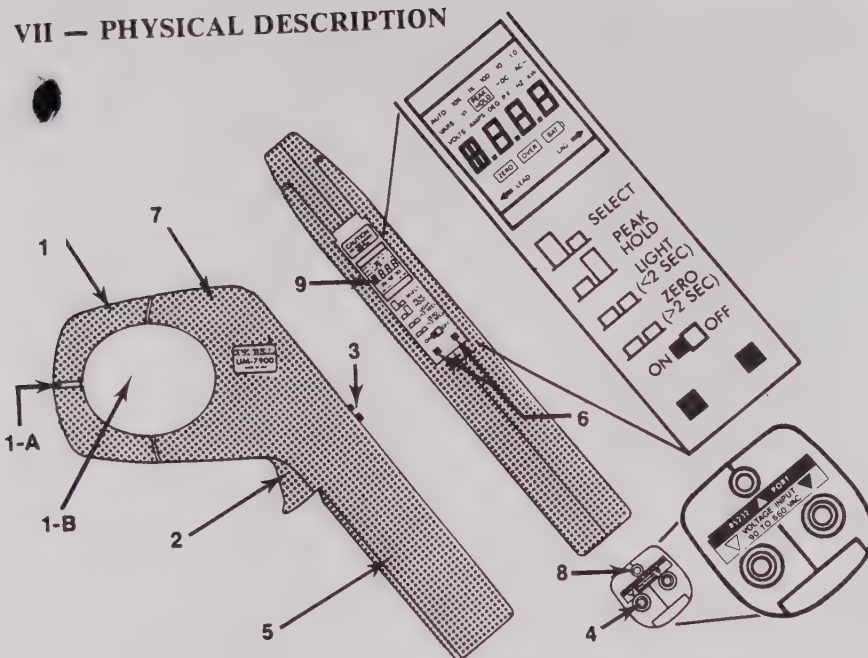
V — APPLICATIONS

- Adjustment of motor loads
- Adjustment of plant loads
- Determination of power factor correction capacitors
- Checking industrial and commercial power systems
- Appliance testing
- Plant maintenance and inspection
- Electrical utility inspection
- Checking frequency
- Determination of current balance between two wires
- Measuring current transformers

VI — FUNCTIONAL DESCRIPTION

The F.W. Bell Model UM-7900 Utility Master is a hand-held, battery-operated digital "SMART" meter designed to provide electrical and electronic service personnel a single instrument capable of handling all their measurement needs. The UM-7900 allows direct measurement of ac voltage, ac and dc current, frequency, power factor, phase-angle, true power, apparent power and reactive power. The meter incorporates the same user-friendly pistol shape utilized in Bell's broad line of current and power meters and probes, providing rugged, well-balanced, one-handed operation. Its large aperture and high current capability make it ideal for utility and plant personnel.

VII — PHYSICAL DESCRIPTION



1. JAWS: Jaws open to accept up to $2\frac{3}{8}$ " diameter conductors. Insulated except at core closure (1-A).

CAUTION: DO NOT USE ON BARE CONDUCTORS OR AT VOLTAGES ABOVE 660 Vac (SINE).

NOTE: Inspect core closure (1-A) frequently for foreign material. Avoid snapping the jaws shut as this can damage the core. Centering of conductors smaller than $2\frac{3}{8}$ " diameter within the aperture (1-B) is desirable, but not critical within specified accuracy limits.

2. JAW TRIGGER: Designed for easy, one-hand opening of jaws. Positioned for maximum protection from circuit voltages.

3. ON/OFF SWITCH: Applies power to the meter. (Left = ON.)

4. VOLTAGE INPUT JACKS: Two connectors designed to accept safety-shrouded banana-type jacks, used for voltage measurement. The red and black arrows above the connectors facilitate proper phasing between the voltage and current waveform.

5. BATTERY COMPARTMENT: Accessed by sliding battery compartment door back. Battery snap will accept a commercial 9-volt alkaline battery.

NOTE: Support the battery snap when removing to prevent unnecessary stress on the battery leads.

6. FUNCTION SWITCHES: Momentary pushbutton switches used to select the various functions of the meter.

7. CASE: High-impact, high-dielectric ABS precision-molded plastic.

8. RS232 JACK: Used to interface to serial printer, terminal, modem, etc.

9. DISPLAY: Custom-formatted, illuminated liquid crystal display for direct readout of measurements.

VIII — OPERATIONAL PROCEDURE

1. BATTERY INSTALLATION: Place the ON/OFF switch in the OFF position. Turn the meter upside down with the battery arrow towards you. Place thumb in notch and apply moderate pressure in the direction of the arrow until door slides open. Locate battery snap and install a 9-volt battery (Eveready alkaline No. 522, NEDA 1640A, or equivalent). Slide battery door to the closed position.

NOTE: Support the battery snap when removing battery to avoid unnecessary stress on the battery leads. Observe battery polarity.

2. VOLTAGE INPUT LEADS: Install the voltage input leads into the jacks in the handle of the meter, observing the polarity indicated by the colored arrows (RED = signal, BLACK = neutral). If making current measurements only, the voltage leads are not needed.

NOTE: Exercise great care when attaching voltage lead clips to voltage source to avoid personal injury.

CAUTION: DO NOT USE AT VOLTAGES ABOVE 660 Vac (SINE).

3. ON/OFF SWITCH: Slide the power switch to the ON position. Initially, the display will appear as in Fig. 1.

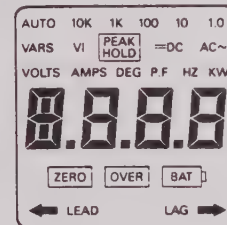


Fig. 1

During this time the meter is performing a test of all internal circuitry. Once these tests are complete (about 5 seconds), the meter is ready to be "zeroed", and the display will appear as in Fig. 2.

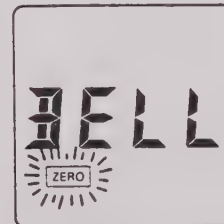


Fig. 2

At this point local control is initiated by proceeding to Step VIII-4. To initiate remote control proceed to Step X-2.

NOTE: If one of the internal tests fail, an error code will be displayed on a continuous basis. Try replacing the battery, but if the failure persists, return the meter to the factory for repair.

4. ZEROING: The process of zeroing the meter provides the most accurate readings when making dc current measurements (no other measurements are affected by this process). Magnetic fields from adjacent conductors, large ferrous objects and from the earth itself, as well as internal circuit offsets and temperature effects, can contribute to inaccurate readings.

To cancel these effects, select a point along the conductor where the stray fields should be at a minimum. Hold the meter perpendicular to the conductor, and about two to four inches (5 to 10 cm) from it.

If you have just turned the meter on and a flashing ZERO is being displayed, press and release both pushbuttons to initiate the zeroing process. If you wish to rezero the meter any time after this, press and hold both pushbuttons for longer than two seconds to initiate the zeroing process. In either case, the display will appear as shown in Fig. 3.

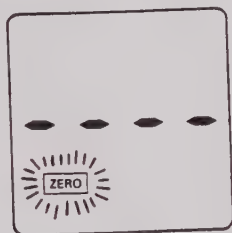


Fig. 3

Upon completion (about 2 seconds), the display will indicate the condition of the serial port (See Figs. 4 and 5), followed by the VOLTS-AC mode. Normal operations may begin at this point.

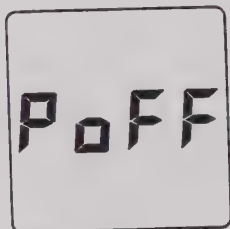


Fig. 4

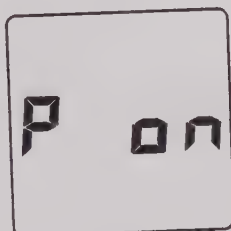


Fig. 5

See Section IX Measurement Notes for further information on zeroing the meter.

5. FUNCTION SELECTION: Pressing and releasing the FUNCTION SELECT (right-hand) pushbutton allows you to step through the various readings as follows:

NOTE: See "Measurement Notes" for further information about these functions.

VOLTS AC: The ac voltage reading represents the true rms value of the voltage waveform. If no ac waveform is detected on the voltage input jacks, or if the voltage is below 1.0 volt, the reading will be displayed as 0.0. Readings will be displayed as 1.0 to 999.9 volts.

NOTE: Readings that are accompanied by a flashing OVER indicator, or that are below 90.0 volts, may not be accurate.

AMPS AC: The ac current reading represents the true rms value of the current waveform. This value does not include the average dc component in the waveform, if any. If no ac waveform is detected through the aperture, or if the current is below 1.0 amp, the reading will be displayed as 0.0. Readings will be displayed as 1.0 to 1000.0 amps.

NOTE: Readings that are accompanied by a flashing OVER indicator may not be accurate.

AMPS DC: The dc current reading represents the average dc value of the current input, whether the current is pure dc or an ac waveform with a dc component. In the latter case, the reading will only show average dc current above 20 amps. To obtain the most accurate reading, the meter should be zeroed before the measurement is performed. Readings will be displayed as 0.0 to 1500.0 amps.

NOTE: Readings that are accompanied by a flashing OVER indicator, or that are below 1.0 amp, may not be accurate.

The direction of the current flow through the aperture is indicated by one of two display arrows, as seen in Figs. 6, 7 and 8.

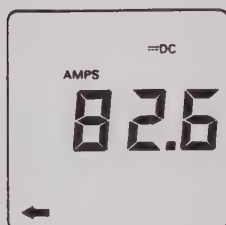


Fig. 6

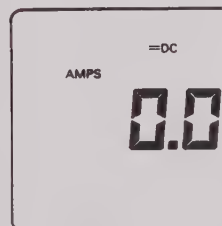


Fig. 7

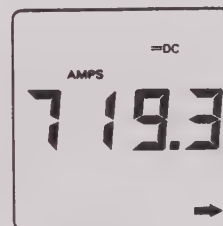


Fig. 8

DEG: The phase relationship between the fundamentals of the voltage and current waveforms is displayed in degrees. If no ac waveform is detected on the voltage input or through the aperture, or the two waveforms are exactly in phase, the reading will be 0.0 degrees. Otherwise the readings will range from 0.1 to 180.0 degrees, accompanied by either the LEAD or LAG display indicator (current leads voltage or current lags voltage). Both indicators will be off if the angle is exactly 0.0 or 180.0 degrees. See Figs. 9 and 10.



Fig. 9

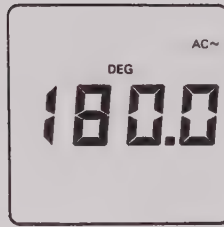


Fig.10

P.F.: Power Factor is a measure of how effectively a device is utilizing the available power, and will range between 0.000 and 1.000. The larger the number, the more efficient the use of available power. If no ac waveform is detected on the voltage input or through the aperture, or the waveforms are completely out of phase (180 degrees), the reading will be 0.000. As with phase-angle readings, the power factor reading is accompanied by the LEAD or LAG indicator to indicate whether the current leads or lags the voltage. For further information See Measurement Note IX-10.

HZ: Frequency is displayed in cycles per second (Hertz). Frequency is measured on the voltage or current input, depending on which waveform is present. If both are present, the frequency is derived from the voltage input. If neither waveform is present, or the frequency is below the minimum range of the meter (40 Hz), the reading will be 0.0. Readings below 1000 Hz will be displayed as 40.0 to 999.9 Hz.

NOTE: Readings that are accompanied by a flashing OVER indicator may not be accurate.

KW: True power is displayed in 1000's of watts, and is a measure of the rate of energy consumption. If no ac waveform is detected on the voltage input or through the aperture, or the voltage and/or current is below the minimum range of the meter, the reading will be 0.0. Readings will be displayed as 0.1 to 999.9 kW. As with phase-angle readings, the true power reading is accompanied by the LEAD or LAG indicator to indicate whether the current leads or lags the voltage.

VAR: Reactive power is displayed in 1000's of reactive volt-amps, and is a measure of the rate of energy storage. If no ac waveform is detected on the voltage input or through the aperture, or the voltage and/or current is below the minimum range of the meter, the reading will be 0.0. Readings will be displayed as 0.1 to 1000 kVAR. As with phase-angle readings, the reactive power reading is accompanied by the LEAD or LAG indicator to indicate whether the current leads or lags the voltage.

VI: Apparent power is displayed in 1000's of volt-amps (VA), and is a measure of the rate of energy consumption with no consideration of the phase-angle between the two waveforms. If no ac waveform is detected on the voltage input or through the aperture, or the voltage and/or current is below the minimum range of the meter, the reading will be 0.0. Readings will be dis-

played as 0.1 to 1000 kVA. As with phase-angle readings, the apparent power reading is accompanied by the LEAD or LAG indicator to indicate whether the current leads or lags the voltage.

6. PEAK HOLD SELECTION: The PEAK HOLD function is used to display the highest readings that have occurred since the PEAK HOLD function was turned on. All readings (volts, amps, frequency, etc.) are affected by PEAK HOLD.

NOTE: When the PEAK HOLD function is turned on, **ALL** peak readings (volts, amps, frequency, etc.) are being held internally, regardless of which of the peak readings is currently being displayed.

The PEAK HOLD function can be turned on or off by pressing and releasing the PEAK HOLD (left-hand) pushbutton. When on, the PEAK HOLD indicator will appear, as in Fig. 11.

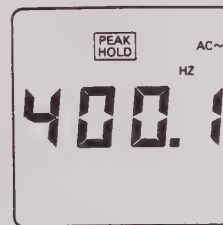


Fig. 11

PEAK HOLD can also be used when making measurements in hard-to-reach places. The meter can be clamped around the conductor (or connected to the voltage source), the PEAK HOLD function turned on, and then the meter removed. The reading will be held as long as PEAK HOLD is on.

See Section IX Measurement Notes for further information.

7. LOW BATTERY INDICATOR: The low battery indicator will flash when battery voltage drops to 6-volts. The battery should be replaced as soon as possible. See Fig. 12.

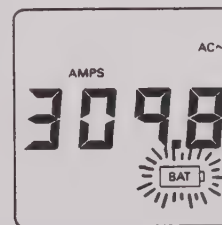


Fig. 12

NOTE: The accuracy of the readings cannot be guaranteed when the low battery indicator is flashing.

3. LCD ILLUMINATION: For viewing in low light conditions, press both pushbuttons for less than two seconds. (Holding the pushbuttons for longer than two seconds will cause the meter to rezero.) The illuminating lamps will turn on for about 10 seconds, and then turn off automatically. Or, the lamps can be turned off by pressing and releasing both pushbuttons again. Battery life will decrease if the illumination feature is used often.

IX — MEASUREMENT NOTES

1. WARM-UP: In the AMPS DC mode, there will be some drifting in the reading during the first 60 to 120 seconds of warm-up. For the most accurate readings, wait this long before making measurements.

2. ZEROING: For maximum accuracy in the AMPS DC mode, rezero the meter before each measurement. When the meter is exposed to relatively high current, a residual magnetism can be left in the core that may result in an offset reading of several amps. This can be removed by rezeroing the meter.

3. RELATIVE ZEROING: In some instances, when measuring dc current, it may be desirable to zero the meter around a conductor carrying a non-zero current in order to use that current as a reference. This is called relative zeroing.

For example, the user may want to measure variations on a conductor that normally carries 200 amps dc, flowing right to left, <— . The user can rezero the meter with 200 amps flowing through the aperture. From then on, readings will reflect the change around the 200 amp mark. Thus, a current of 210.3 amps will read 10.3 amps, <— , and a current of 175.9 amps will read 24.1 amps, —> . If the PEAK HOLD function has been turned on, the held reading will be 24.1, —> .

4. MULTI-TURN MEASUREMENTS: Where possible, when making low-level current or power measurements, looping a number of turns of the current-carrying conductor through the aperture will multiply the sensitivity of the readings. To obtain the correct current or power readings, divide the reading by the number of turns.

5. CORE CLOSURE: Foreign material in the core closure area can prevent the jaws from fully closing, causing inaccurate current and power readings.

6. IDLE MODE: To conserve power in the event that the meter is accidentally left on for more than five minutes, the meter will go to a low-power IDLE state, and the word IDLE will appear on the display, as in Fig. 13.

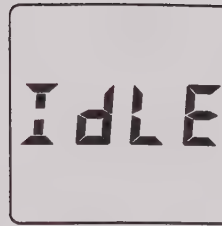


Fig. 13

The meter will no longer respond to the pushbuttons or commands from the serial port in this state, and the user must turn the power OFF and ON again to resume normal operations. Certain conditions must be met before the meter will allow itself to go IDLE:

Five minutes has elapsed and...

- The PEAK HOLD function has been OFF, and...
- Neither pushbutton has been pressed, and...
- No device is connected to the serial port, and...
- Voltage readings have been less than 10.0 volts, and...
- ac and dc current readings have been less than 1.0 amp.

The meter can remain in the IDLE state for over 30 hours (continuous) before the battery needs to be replaced.

7. OVER INDICATOR: A flashing OVER indicator means that either the voltage, current, or frequency has exceeded the maximum range of the meter, past which point the accuracy of the readings cannot be guaranteed. For frequency, the trigger point is 500 Hz.

For voltage and current, the trigger points are based on the peak values, of either the positive or negative portion of the waveforms rather than their true rms value. For voltage this is about 933 volts peak; for current about 1414 amps peak.

To further illustrate this point, a sinusoidal voltage waveform whose peak value is 940.0 volts will have a true rms value of 664.7 volts, and will trigger the OVER indicator. A square voltage waveform whose peak value is 850.0 volts will have a true rms value of 850.0 volts and will not trigger the OVER indicator.

The OVER indicator is also used to tell the user that some reading other than the one being displayed is affecting the accuracy of the one being displayed. For instance, if the KW (actual power) reading is being displayed, but the voltage input has exceeded the range of the unit (and thus is affecting the accuracy of the actual power reading), the flashing OVER indicator will appear along with a flashing VOLTS indicator, as seen in Fig. 14.

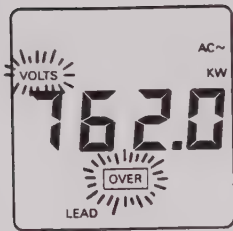


Fig. 14

8. PEAK HOLD USAGE: The PEAK HOLD function allows the user to capture and hold peak readings on the voltage and current inputs. This is especially useful when determining peak loads over a period of time, or for locating intermittent overloads on a line.

ALL peak readings are held internally when the PEAK HOLD function is on (not just the one being displayed). The user can scan through each reading to obtain the peak values for each measurement.

For voltage, current and frequency, the highest readings are held, along with their associated OVER indicators (if needed).

When measuring dc current, the highest reading will be held, regardless of current direction, and the associated direction indicator (<— or —>) will be held along with the peak reading.

For phase-angle, power factor and the three power readings, the highest values will be held, regardless of the lead or lag relationship of the voltage and current waveforms, and the associated LEAD or LAG indicator will be held along with the peak readings.

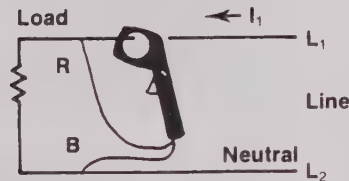
As mentioned previously, the PEAK HOLD function can be used to make measurements in hard-to-reach places by clamping the meter around the conductor (or connecting to the voltage source), turning on the PEAK HOLD and then removing the meter from the conductor or voltage source to observe the reading.

Note that when in the AMPS DC mode, a reading of several amps may appear when the jaws are open. If using this method to measure low dc currents in hard-to-reach places, opening the jaws may affect the peak reading. Also note that when using this method to measure voltage, the user should have the voltage input cables clamped to the voltage source before turning the PEAK HOLD on. This will prevent false peak readings caused by momentary inrush currents and contact uncertainties.

9. POWER MEASUREMENTS: Single- and multi-phase power may be measured by connecting the UM-7900 as shown in the Figs. 15, 16, 17 and 18.

TYPICAL CONNECTION SCHEMES

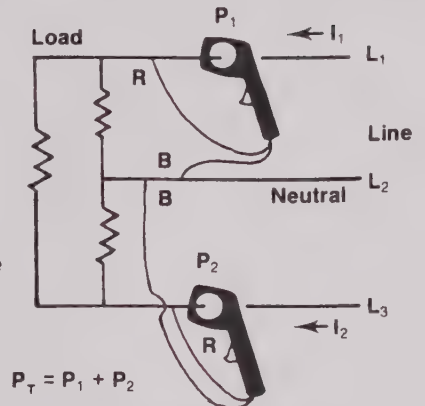
NOTE: "R" = Red, "B" = Black



$$P_T = P$$

Single-Phase

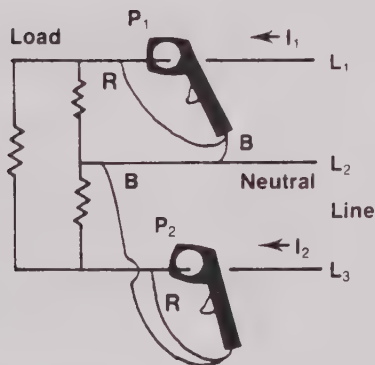
Fig. 15



$$P_T = P_1 + P_2$$

Single-Phase, 3-Wire

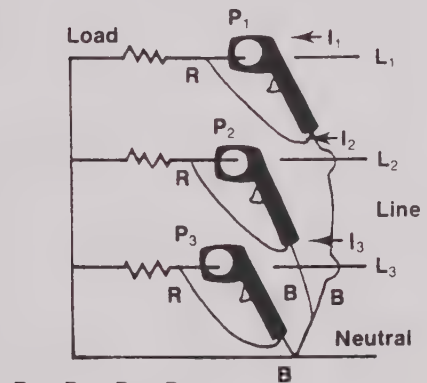
Fig. 16



$$P_T = P_1 + P_2$$

Three-Phase, 3-Wire, Delta or γ

Fig. 17



$$P_T = P_1 + P_2 + P_3$$

Three-Phase, 4-Wire

Fig. 18

10. POWER FACTOR MEASUREMENTS: Power factor is defined as follows: $PF = \mu \cos \phi$ where PF = Power Factor; μ = Distortion Factor for non-sinusoidal waveforms ($\mu = 1$ for sinusoidal waveforms); $\cos \phi$ = Displacement Factor. The power factor ranges from 1.000 when the voltage and current waveforms are in phase (such as in a resistive circuit) to something less than 1.000 (such as when the load is inductive or capacitive) when the two waveforms are no longer in phase. In order to provide the most accurate indication of power factor regardless of waveform, the UM-7900 calculates the power factor by dividing the real power by the apparent power.

THE IMPORTANCE OF MEASURING POWER FACTOR

In practice, the power factor of a load is very important. In industrial applications, in loads requiring thousands of watts to operate, the power factor greatly affects the cost of operation. For example, if an assembly plant consumes 100 kW from a 220 V rms line, and has a power factor of 0.850, the current drawn will be 534.8 amps, and the apparent power will be 117.7 kVA. Now if the power factor is increased to 0.950, the amount of current drawn is reduced to 478.5 amps, and the apparent power is reduced to 105.3 kVA.

Power factor also can dramatically influence the life of devices such as motors and heating elements. For instance, less efficient motors must draw more current to do the same amount of work, causing them to operate at higher temperatures, thus shortening their operational life.

11. INDUCED (FALSE) VOLTAGE READINGS: If the UM-7900 is exposed to extremely large magnetic fields, the fields may induce signals in the internal circuitry that may result in false voltage readings of one to five volts. For safety reasons the UM-7900 will display any voltage level above 1.0 volt because it cannot determine if the voltage is real or induced. The meter is designed to compute power, power factor or phase-angle on any voltage reading above 1.0 volts.

If making current measurements only, and the false voltage readings are bothersome, connect the voltage input leads to the meter and clamp the lead clips to each other.

X — RS232 (SERIAL) PORT OPERATION

Located in the handle of the UM-7900 is a serial communications port jack designed to interface with printers, dumb terminals, modems or personal computers (see "Specifications" for interface data).

An adapter cable (included with each UM-7900) plugs into the RS232 port jack and terminates with a standard 25-pin "D" type connector:

"D" Connector Pin Number	Interface Description
1	External device chassis ground
2	Receive data (RX) from external device to UM-7900
3	Transmit data (TX) from UM-7900 to external device
7	Signal ground

Some serial devices have Pins 2 and 3 functionally reversed, and may require an additional adapter which is available from most computer stores. Some devices may be reconfigured internally. Refer to the device's operating manual.

Extension cables also are available from most computer stores. The total length of the cable, including that supplied with the meter, should not exceed 15 feet (4.5 meters).

1. STANDARD (HARDCOPY) OPERATION; The most common use of the serial port is to obtain a continuous hardcopy of readings, using a printer, or to monitor the readings from a remote site using a dumb terminal or computer. To do this, simply attach the device to the UM-7900.

NOTE: If the device is attached after the meter has been turned on, you must rezero the meter (or turn it off and on again) to start transmission.

Once started, the UM-7900 will transmit, on a continuous basis, a formatted table containing the most recent readings and status information.

The first four lines of ASCII information transmitted are a descriptive header. Contained in this header are the present UM-7900 software version number, and column descriptors. Sixty lines of readings will follow the header. Each line is followed by a CARRIAGE RETURN <CR> and LINE FEED <LF> control character. The final line is also followed by a FORM FEED <FF> control character, and then a new header. If the meter is rezeroed, the transmission will start over, beginning with the header.

SAMPLE HARDCOPY PRINTOUT F.W. Bell Utility Master UM-7900 Version 1.3

Volts	Amps-ac	Amps-dc	DEG	PF	Hz	kW	kVAR	kVA	I<>V	HLD	BAT
120.3	450.0	< 0.1	121.1	0.517	60.0	28.0	46.4	54.1	LEAD	OFF	OK
90.9	8.5	0.0	0.0	1.000	400.1	0.8	0.0	0.8		OFF	OK
680.3^	0.0	> 29.4	0.0	0.000	50.1	0.0	0.0	0.0		OFF	OK
440.5	100.0	0.0	45.7	0.698	60.0	30.8	31.5	44.1	LAG	ON	OK
220.0	1010^	< 0.2	1.1	0.999	59.9	222.2	4.3	222.2	LAG	ON	LOW
110.7	0.0	>100.9	0.0	0.000	500.6^	0.0	0.0	0.0		OFF	LOW
.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.

The HLD column indicates if the PEAK HOLD is on or off. The BAT column indicates battery status. The > or < in the Amps-dc column indicates the direction of current flow. The ^ indicates that an overrange condition exists on that reading.

2. REMOTE CONTROL OPERATION: The UM-7900 also can be controlled remotely from a computer or dumb terminal (called the "Host") by sending a series of ASCII command strings to the UM-7900.

The command strings are from three to four characters long. Each begins with the ASCII ESCAPE <ESC> control character and ends with a CARRIAGE RETURN <CR> character. Upon successful completion of the requested operation, the UM-7900 will send the command string back to the Host. This is an indication that the operation was performed, and that the Host may issue another command. If an illegal command string was received, or the received command string contained a transmission error, the UM-7900 will return a <ESC> <ESC> <CR> error code instead.

In the remote mode, the meter does not make new measurements and update the display with new readings on a continuous basis. It does so only upon the reception of any command (legal or not) from the Host, and will hold that reading until the next command is received. The meter remains inactive between commands. Also note that the meter does not transmit readings to the Host unless requested to do so. Thus, the readings on the display may not reflect present conditions on the voltage inputs or through the aperture.

The pushbuttons, however, remain active in the remote mode, and perform the same functions as during normal operation.

NOTE: If the rezeroing process is initiated via the pushbuttons (by pressing both for longer than two seconds), the remote mode of operation will be terminated.

3. EXPLANATION OF REMOTE CONTROL COMMANDS

(A) ENTER REMOTE MODE COMMAND: <ESC>A<CR>

The REMOTE mode of operation can be entered only at the point where the meter has been powered up and is waiting for the initial zeroing sequence (BELL and flashing ZERO indicator on the display). If the user manually zeroes the meter (via the pushbuttons), the remote mode can no longer be entered, and the meter will begin transmission of readings, as described previously.

When the <ESC>A<CR> command string is issued, the AUTO indicator will begin flashing and the meter will proceed with the zeroing process (see previous discussions on zeroing). See Fig. 19.

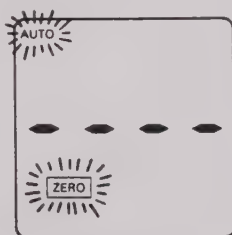


Fig. 19

The flashing AUTO indicator will remain on as long as the meter is being controlled remotely, and is intended to remind anyone near the meter that the meter is in use.

Once the zeroing process is complete, the meter will display VOLTS AC and return the command to the Host. If the Host issues further <ESC>A<CR> commands, a new measurement will be taken and the display updated, but the meter will not rezero.

(B) EXIT REMOTE MODE COMMAND: <ESC>X<CR>

The remote mode can be terminated with the <ESC>X<CR> command. The meter will return the command to the Host and then proceed as if the meter had just been turned on.

(C) REZERO COMMAND: <ESC>Z<CR>

This command forces the meter to rezero. When finished, the command will be returned to the Host.

(D) PEAK HOLD OFF COMMAND: <ESC>P0<CR>

This command cancels the PEAK HOLD function.

(E) PEAK HOLD on COMMAND: <ESC>P1<CR>

This command initiates the PEAK HOLD function.

(F) SEND READINGS COMMAND: <ESC>S<CR>

This command causes the meter to transmit a formatted ASCII string containing all readings and meter status. Note that the readings that are transmitted are those that were present before the <ESC>S<CR> command was received. Upon completion of the transmission, new measurements are taken and the display is updated, and then the <ESC>S<CR> command is returned to the Host.

There are 72 characters in the string, followed by the returned command string (<ESC>S<CR>). The data string is segmented into a number of fields, defined as follows:

(NOTE: In the following examples, the "*" character is used to denote the ASCII SPACE (" ") character, and is used only for clarity in reading this document. The "*" is not actually transmitted.)

**EXAMPLE OF A 72-CHARACTER STRING
WITH TYPICAL READINGS**

Character #	Description
1 - 5	VOLTS ac Ex: **0.0, *92.6, 435.8, 1139*
6	ASCII SPACE OR ^ (overrange on voltage)
7	ASCII SPACE
8 - 12	AMPS ac Ex: **0.0, *92.6, 435.8, 1139*
13	ASCII SPACE OR ^ (overrange on current)
14	ASCII SPACE
15 - 20	AMPS dc Ex: ***0.0, >*92.6, <435.8, >1139*
21	ASCII SPACE OR ^ (overrange on current)
22	ASCII SPACE
23 - 27	PHASE ANGLE Ex: **0.0, *45.2, 179.8
28	ASCII SPACE
29 - 33	POWER FACTOR Ex: 0.000, 0.456, 1.000
34	ASCII SPACE
35 - 39	LINE FREQ. Ex: **0.0, *60.1, 400.3, 1200*
40	ASCII SPACE OR ^ (overrange on frequency)
41 - 45	ACTUAL PWR Ex: **0.0, *90.3, 850.0, 1139*
46	ASCII SPACE
47 - 51	REACTIVE PWR Ex: **0.0, *90.3, 850.0, 1139*
52	ASCII SPACE
53 - 57	APPARENT PWR Ex: **0.0, *90.3, 850.0, 1139*
58	ASCII SPACE
59 - 62	LEAD/LAG Ex: ****, LEAD, LAG*
63	ASCII SPACE
64 - 66	PEAK HOLD Ex: OFF, ON*
67	ASCII SPACE
68 - 70	BATTERY Ex: LOW, OK*
71	CARRIAGE RETURN <CR>
72	LINE FEED <LF>


```

3020 '* WHEN THE COMMAND IS ISSUED THE PROGRAM WILL WAIT A MAXIMUM OF *
3021 '* 10 SECONDS TO RECEIVE THE RESPONSE. IF A RESPONSE IS RECEIVED *
3022 '* THE RESPONSE COMMAND STRING WILL BE IN THE 'RS232.IN$' BUFFER UPON *
3023 '* RETURN. IF NO RESPONSE IS RECEIVED THE PROGRAM WILL TRY TWO MORE *
3025 '* TIMES. IF STILL NO RESPONSE AN ERROR MESSAGE WILL PRINT TO THE SCREEN*
3026 '.....
3030 '
3045 '***** SET UP RS232 COMMUNICATION INTERFACE *****
3050 ON ERROR GO TO 3170
3055 COMM.ERR.TRY = 0: START.TIME.OUT = 0: TIME.OUT.TRY = 0
3060 CR$ = RS232.OUT$ + CHR$(13)
3065 '***** SEND RS232 COMMAND *****
3070 PRINT #1, RS232.OUT$
3085 '***** RECEIVE RS-232 COMMAND*****
3090 RS232.IN$ = "": RS232.PASS = 0
3095 IF EOF(1) THEN 3125
3105 RS232.IN$ = RS232.IN$ + INPUT$(LOC(1),#1) 'NO..READ CHAR FROM FILE 1
3110 RS232.PASS = INSTR(RS232.IN$,CR$) 'LOOKS FOR CORRECT RTN
3115 IF RS232.PASS > 0 THEN 3220 ELSE 3095 'TEST FOR CORRECT RTN
3120 '
3125 '***** COMMUNICATION TIME OUT *****
3130 IF START.TIME.OUT = 1 THEN 3145
3135 START.TIME.OUT = 1
3140 IF TIMER > 86394! THEN START.TIME = 0 ELSE START.TIME = TIMER
3145 IF TIMER - START.TIME < 10 THEN 3095
3150 TIME.OUT.TRY = TIME.OUT.TRY + 1
3155 IF TIME.OUT.TRY > 3 THEN 3190
3160 START.TIME.OUT = 0: GO TO 3065
3165 '
3170 '***** COMMUNICATION ERROR *****
3175 COMM.ERR.TRY = COMM.ERR.TRY + 1
3180 IF COMM.ERR.TRY > 3 THEN RESUME 3190 ELSE RESUME 3065
3185 '
3190 '***** FAILED COMMUNICATION TEST *****
3195 PRINT "==== PROBE FAILED RS-232 COMMUNICATION INTERFACE ===="
3220 '***** PASSED COMMUNICATION TEST *****
3240 ON ERROR GOTO 0
3245 RETURN

```

XII — THEORY OF OPERATION

The UM-7900 is a microcontroller-based current/voltage probe capable of digitizing two 500 Hz (or slower) waveforms simultaneously.

The line voltage waveform is obtained from the output of a stepdown transformer located in the handle of the UM-7900 case. The line current waveform is produced by two Hall-effect devices mounted 180 degrees from each other in the core assembly. With the core jaws closed, the magnetic field sur-

XI — UM-7900 DEMO PROGRAM (RS-232 INTERFACE)

```

100 CLS
105 PRINT .....
110 PRINT "                UM-7900 RS-232 DEMONSTRATION PROGRAM                "
115 PRINT .....
120 PRINT "    This program demonstrates the use of the RS-232 port on the    "
125 PRINT "    UM-7900 probe to remotely control the instrument. The program    "
130 PRINT "    is designed to operate from the COM1 communications port on any    "
135 PRINT "    PC.                                                                    "
140 PRINT .....
145 PRINT "    Before beginning connect the communications cable to the probe    "
150 PRINT "    and turn the probe on. Wait for the 'BELL' logo to appear.          "
155 PRINT "    Do not press the pushbuttons.                                         "
160 PRINT .....
170 PRINT .....
175 PRINT: PRINT "Press any key when ready . . . . .";
180 IF INKEY$ = "" THEN 180 ELSE CLS
185 '
200 '
205 '*** PROBE REMOTE COMMAND STRINGS ***'
210 '
215 A$ = CHR$(27) + "A"                'AUTO
220 S$ = CHR$(27) + "S"                'MEASUREMENT
230 '
300 '*** START OF DEMONSTRATION ***'
305 '
310 OPEN "COM1:1200,N,8,1,RS,CS,DS,CD" AS #1      'OPEN COMM PORT
315 PRINT "Programming PROBE for remote control."
320 RS232.OUT$ = A$: GOSUB 3000 'SEND COMMAND
325 '
330 CLS: PRINT "Acquiring measurements . . . press any key to quit.": PRINT
335 PRINT "VOLTS      AMPS-AC      AMPS-DC      DEG      PF      HZ      KW"
KVAR    KVA    I< >V    HLD    BAT"
340 PRINT "----- \----- ----- ----- -----"
-----
345 '
350 FOR I = 1 TO 15
355 RS232.OUT$ = S$: GOSUB 3000      'SEND COMMAND
360 PRINT LEFT$(RS232.IN$,70)        'PRINT RESPONSE
365 IF INKEY$ < > "" THEN 380
370 NEXT I
375 GO TO 330
380 CLOSE #1
390 END
3000 .....
3005 " * THIS SUBROUTINE IS USED TO COMMUNICATE TO AND FROM THE UM-7900 *
3010 " * PROBE OVER THE RS-232 INTERFACE. UPON ENTRY THE "RS232.OUT BUFFER *
3015 " * MUST CONTAIN THE COMMAND STRING TO BE TRANSMITTED TO THE PROBE. *

```


rounding the current-carrying conductor is concentrated and redirected to pass through the Hall devices, causing the Hall devices to generate a voltage directly proportional to the magnetic field (which is directly proportional to the current, whether ac or dc).

The UM-7900 first determines the frequency of the line input and, based on the period of one cycle, measures 360 unique, evenly-spaced points on each waveform (each point is one degree apart from the next). Both waveforms are measured simultaneously in order to determine their phase relationship.

The image of each waveform is then reconstructed and corrected for errors caused by irregularities in the Hall devices, stepdown transformer, core saturation rolloff, frequency-related analog filter rolloff, internal circuit phase shifting and temperature-related drifting. Correction information is generated at the factory for each meter, and stored permanently in the meter.

The true rms values of the voltage and current waveforms are computed, and become the VOLTS-AC and AMPS-AC readings, respectively. All points on the current waveform are averaged to obtain the average dc level of the current input, and become the AMPS-DC reading. Also determined is the direction of the current flow through the aperture.

Next, an image of the real-power waveform is constructed by performing a simultaneous multiplication of each corresponding point on the voltage and current waveforms. At the same time, a second power waveform is constructed by shifting the current waveform by 90° and performing a simultaneous multiplication of each time-corresponding point on the voltage and the shifted current waveform. The average value of the real-power waveform represents the real-power in kW, and the average of the second power waveform provides the reactive power in kVARs. The product of the rms voltage and the rms current provides the apparent power in volt/amperes (VI).

Finally, the power factor is computed by dividing the real power in kW by the apparent power in volt/amperes, and the phase-angle is computed by evaluating the equation: $\phi = \tan^{-1}\left(\frac{\text{kVARs}}{\text{kW}}\right)$. At the same time, the LEAD or the LAG relationship between the current and voltage waveforms is established.

The process of digitizing and analyzing the waveforms and updating the display, takes approximately $\frac{3}{4}$ seconds. Every reading is generated, regardless of which is presently displayed.

If the PEAK HOLD function is engaged, the present readings are compared to the highest readings obtained since the PEAK HOLD was engaged. If mathematically smaller, they are discarded. If larger, they are held and become the new reference for future measurements. All peak readings are held internally, regardless of which is presently displayed.

The microcontroller also controls a full duplex RS232 communications port, monitors battery voltage, processes the pushbutton switches and controls the formatting and illumination of the liquid crystal display.

WARRANTY REGISTRATION CARD

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It will allow us to contact you in case of
a product recall for quality or safety
reasons.

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